XRISM X-Ray Imaging and Spectroscopy Mission

Anatomy of a XRISM Simulation

Originally presented at XRISM Science Team Meeting JAXA/ISAS, May 2019

Updated June 2019

Where and How to Get Stuff

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- Go to XRISM SDC Tools Pre-launch Builds website on confluence/XARM_INTL

https://galaxy.astro.isas.jaxa.jp/confluence/display/XINTL/XRISM+SDC+Tools+Pre-launch+Builds

- "README"s lead to

ftp://legacy.gsfc.nasa.gov/xrism/prelaunch/simulation/sim2/

- Download tarfiles and User Guide "heasim_20170825.pdf"

Spectral Simulations: The Basics

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- This suite of files (in specfiles_v002.tar.gz) is sufficient to assess feasibility (for a given exposure time) of meeting the spectral goals of most prospective XRISM targets. See README_XRISM_SPECFILES.txt for details.
- The files are in-flight hitomi sxs response files (renamed to “resolve”).
- Spectral simulations in the standard way, e.g. XSPEC/fakeit (User Guide SB.1).
- Normalized response matrix (RMF) files that include only the Gaussian core of the line spread function (LSF) are provided, for 4 (constant) values of FWHM:

  resolve_h5ev_2019a.rmf resolve_h7ev_2019a.rmf

  resolve_m6ev_2019a.rmf resolve_m8ev_2019a.rmf
- Note: NXB generally negligible (~0.01 c/s/array), but files corresponding to each of the 4 RMFs described above are now provided.

Spectral Simulations: Effective Area

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Six “ARF”s that convert flux to 0.11-25 keV counts over the full calorimeter array, either with gate-valve open ("noGV") or closed ("withGV”), are provided.

- Includes the (Hitomi SXS) quantum efficiency, optical blocking filter transmission.

name	spatial distribution
resolve_pnt_spec_noGV_20190611.arf	on-axis point source, gatevalve open
resolve_pnt_spec_withGV_20190611.arf	on-axis point source, gatevalve closed
resolve_flt_spec_noGV_20190611.arf	5 arcmin radius uniform circle centered on-axis, gatevalve open
resolve_flt_spec_withGV_20190611.arf	5 arcmin radius uniform circle centered on-axis, gatevalve closed
resolve_bet_spec_noGV_20190611.arf	5.7 arcmin radius beta-model, beta=0.57, 1.26 arcmin core centered on-axis, gatevalve open
resolve_bet_spec_withGV_20190611.arf	5.7 arcmin radius beta-model, beta=0.57, 1.26 arcmin core centered on-axiis, gatevalve closed

For a general extended source, the point source arf should be good to ~25% in converting flux from a small (<array) region to a count rate – when in doubt use that one, or do a full simulation (see below).

Full Simulation: Setup

(1) Follow the instructions to setup and install XRISM_05Dec2018_Build1.

(2) Download and unpack support files and sample scripts:

tar -xvzf heasimfiles_20190619.tar.gz
tar -xvzf heasimscripts_20170830.tar.gz

(3) Set the HEASIM_SUPPORT environment variable:

setenv HEASIM_SUPPORT <heasimfilesdir> (C-shell) or
export XSELECT_MDB=<heasimfilesdir> (Bash) – typo in guide here

(4) Set the XSELECT_MDB environment variable to run *xselect* on your output:

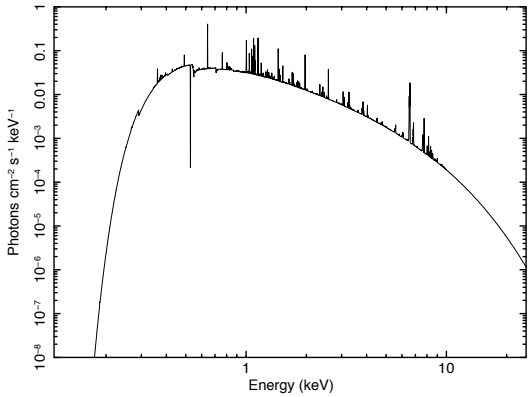
setenv XSELECT_MDB $HEASIM_SUPPORT/auxiliary/xselect.mdb.heasim (C-shell) or
export XSELECT_MDB=$HEASIM_SUPPORT/auxiliary/xselect.mdb.heasim (Bash)

Anatomy of a XRISM “Perseus” Simulation

Step 1: Make Xspec qdp Model Files

In this example “Perseus” = beta model ICM (TBabs*bvvapec) plus point source AGN (Tbabs*plaw)

```
XSPEC12>@perseus_icm_abs_mod.xcm
XSPEC12>data none
XSPEC12>energ 0.1 27.1 27000
XSPEC12>cpd /xs
XSPEC12>setplot comm wdata perseus_icm_abs_mod.qdp
XSPEC12>plot model
```

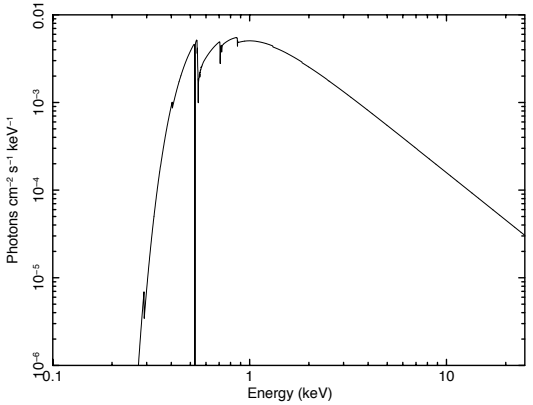


energy range spans the instrument band
energy bin smaller than instrument resolution.

Model should be properly normalized (i.e., give the correct flux).

Combine all components with the same spatial distribution into one model.

```
XSPEC12>@perseus_brtptsrc_mod.xcm
XSPEC12>data none
XSPEC12>energ 0.1 27.1 27000
XSPEC12>cpd /xs
XSPEC12>setplot comm wdata perseus_brtptsrc_mod.qdp
XSPEC12>plot model
```



Step 2: Make source definition files

perseus_betaicm.dat ==
49.95,41.51,0.0,user,0.,0.,0.-0.,perseus_icm_abs_mod.qdp,2,2,extmod(beta,0.53,1.26,1.0,0.0,0.0,5.7)
49.95,41.51,0.0,user,0.,0.,0.-0.,perseus_brtptsrc_mod.qdp,2,2

RA,DEC,NH,spectrum,flux,bandpass,specfile,specunits,specformat,source_specifications

RA,DEC	source coordinates.
NH	column density: set to 0 if absorption is included in the input spectrum.
spectrum	“user” if using input spectrum.
flux	source flux in erg/sec/cm^2: set to 0 if using an input spectrum (flux is calculated from that).
bandpass	bandpass within which flux is calculated: set to 0.0-0.0 if using an input spectrum.
specfile	qdp file name: see guide for other formats.
specunits	2 for specfile derived as shown: see guide for other options tied to specfile.
specformat	2 for specfile derived as shown: see guide for other options tied to specfile.
source_specs	extended spatial distribution, or time variation, specifier (if any) Here, a beta=0.53, core radius =1.26 arcmin beta-model extending to 5.7 arcmin. The specified flux corresponds to this distribution.

Step 3: Run the (on-axis) Simulations

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```
heasim mission=hitomi instrume=sxs rapoint=49.95 decpoint=41.51 roll=0.00 exposure=200000.
  insrcdeffile=perseus_betaicm_brptsrc.dat outfile=perseus_betaicm_brptsrc.fits
  psffile=$HEASIM_SUPPORT/hitomi/sxs/psf/eef_from_sxs_psfimage_20140618.fits
  vigfile=$HEASIM_SUPPORT/hitomi/sxs/vignette/SXT_VIG_140618.txt
  rmffile=$HEASIM_SUPPORT/hitomi/sxs/response/resolve_h5ev_2019a.rmf
  arffile=$HEASIM_SUPPORT/hitomi/sxs/response/resolve_pnt_heasim_noGV_20190611.arf
  intbackfile=none flagsubex=no seed=1234567890 clobber=yes
```

NOTE: We (now) recommend using a single point source arf and including vignetting.

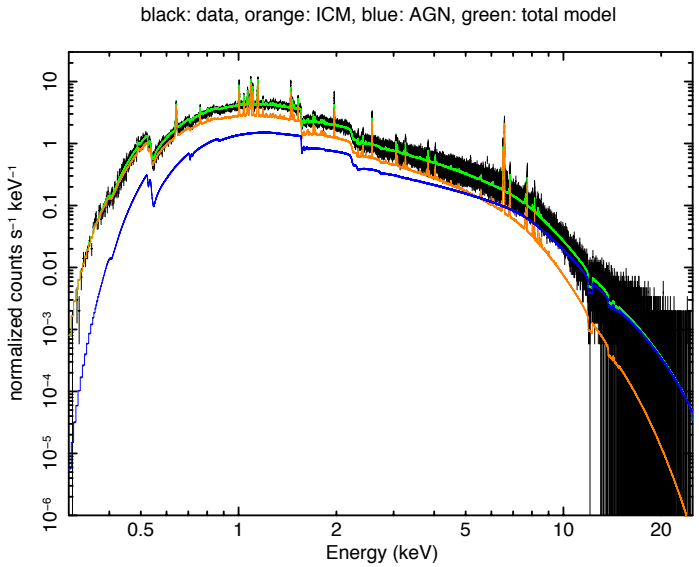
Step 5: Extract and Fit the Spectra

Spectra may be extracted using xselect within the HEASIM_SUPPORT environment, and fit using Xspec.

```
XSPEC12>data 1:1 perseus_betaicm_brptsrc_merged_sorted.pi
XSPEC12>response  1:1 resolve_h5ev_2019a.rmf
XSPEC12>response  2:1 resolve_h5ev_2019a.rmf
XSPEC12>arf 1:1 resolve_bet_spec_noGV_20190611.arf
XSPEC12>arf 2:1 resolve_pnt_spec_noGV_20190611.arf
XSPEC12>model  TBabs*bvvapec
XSPEC12>... specify params
XSPEC12>model  2:agn constant*TBabs*powerlaw
XSPEC12>... specify params
```

Note: Different ARFs from that used as heasim input.

Note: Count rate is “correct”; use appropriate extended source ARF to recover input flux.

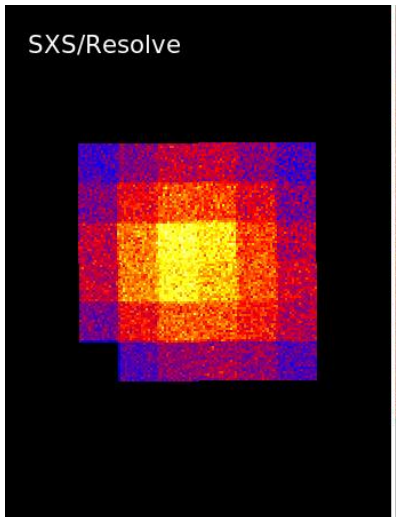


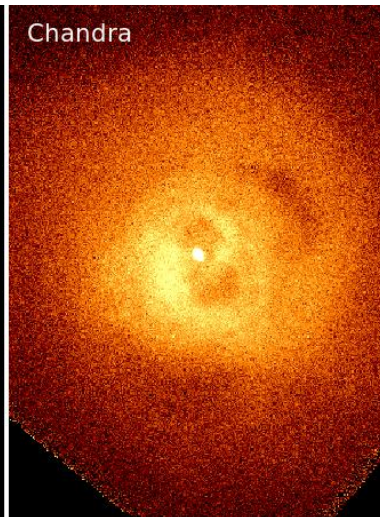
You may wish to... Use an Image

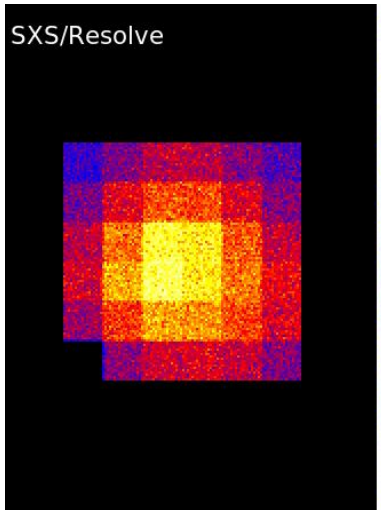
perseus_imageicm.dat == 49.95,41.51,0.0,user,0.,0.,0.-0.,perseus_icm_abs_mod.qdp,
2,2,image(**acis_chip0_band1_norm.img**,0,0,0,0)

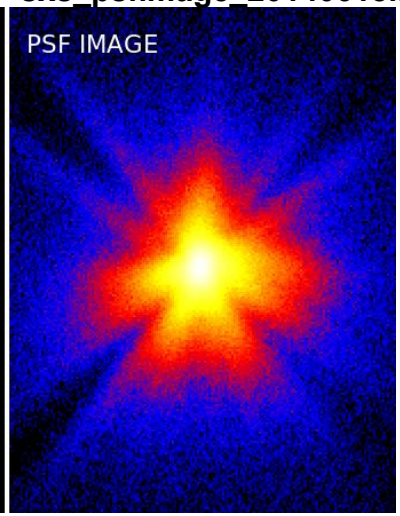
heasim mission=hitomi instrume=sxs rapoint=49.95 decpoint=41.51 roll=0.00 exposure=200000.
insrcdeffile=**perseus_imageicm.dat** outfile=perseus_imageicm.fits psffile=$HEASIM_SUPPORT/hitomi/sxs/psf/
eef_from_sxs_psfimage_20140618.fits vigfile=$HEASIM_SUPPORT/hitomi/sxs/vignette/SXT_VIG_140618.txt
rmffile=$HEASIM_SUPPORT/hitomi/sxs/response/resolve_h5ev_2019a.rmf arffile=$HEASIM_SUPPORT/hitomi/sxs/
response/resolve_pnt_heasim_noGV_20190611.arf intbackfile=none flagsubex=no seed=1234567890 clobber=yes

sxs_psfimage_20140618.fits







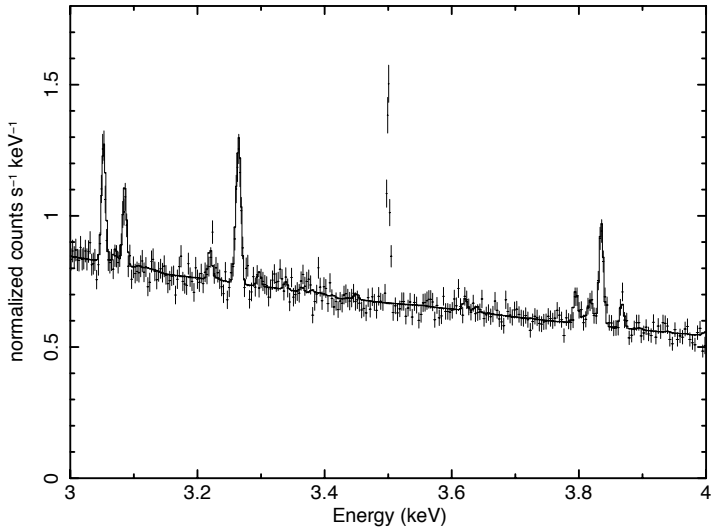


You may wish to... Add a line

perseus_betaicm_brptsrc_line.dat ==
49.95,41.51,0.0,user,0.,0.,0.-0.,perseus_icm_abs_mod.qdp,2,2,extmod(beta,0.53,1.26,1.0,0.0,0.0,5.7)
49.95,41.51,0.0,user,0.,0.,0.-0.,perseus_brtptsrc_mod.qdp,2,2
49.95,41.51,0.0,**mono,3.5**,1.0e-13,2.5-4.5,none,2,2,**extmod(beta,0.66,0.1,1.0,0.0,0.0,5.7)**

heasim mission=hitomi instrume=sxs rapoint=49.95 decpoint=41.51 roll=0.00 exposure=200000.
insrcdeffile=**perseus_betaicm_brptsrc_line.da**t outfile=perseus_betaicm_brptsrc_line.fits...

mono: narrow gaussian line
For finite width use user model



You may wish to... Use a FW ARF

heasim mission=**astro-h** instrume=sxs rapoint=49.95 decpoint=41.51 roll=0.00 exposure=200000. insrcdeffile=perseus_betaicm_brptsrc.dat outfile=perseus_betaicm_brptsrc.fits psffile=$HEASIM_SUPPORT/**astro-h**/sxs/psf/eef_from_sxs_psfimage_20140618.fits vigfile=$HEASIM_SUPPORT/**astro-h**/sxs/vignette/SXT_VIG_140618.txt rmffile=$HEASIM_SUPPORT/**astro-h**/sxs/response/**ah_sxs_5ev_20130806.rmf** arffile=$HEASIM_SUPPORT/**astro-h**/sxs/response/**sxt s_140505_ts02um_Be_intall_140618psf.arf** intbackfile=none flagsubex=no seed=1234567890 clobber=yes

In Xspec, use **ah_sxs_5ev_20130806.rmf**, **sxt-s_140505_ts02um_Be_intallpxl.arf**

heasim mission=**astro-h** instrume=sxs rapoint=49.95 decpoint=41.51 roll=0.00 exposure=200000. insrcdeffile=perseus_betaicm_brptsrc.dat outfile=perseus_betaicm_brptsrc.fits psffile=$HEASIM_SUPPORT/**astro-h**/sxs/psf/eef_from_sxs_psfimage_20140618.fits vigfile=$HEASIM_SUPPORT/**astro-h**/sxs/vignette/SXT_VIG_140618.txt rmffile=$HEASIM_SUPPORT/**astro-h**/sxs/response/**ah_sxs_5ev_20130806.rmf** arffile=$HEASIM_SUPPORT/**astro-h**/sxs/response/**sxt s_140505_ts02um_ND_intall_140618psf.arf** intbackfile=none flagsubex=no seed=1234567890 clobber=yes

In Xspec, use **ah_sxs_5ev_20130806.rmf**, **sxt-s_140505_ts02um_ND_intallpxl.arf**

heasim mission=**astro-h** instrume=sxs rapoint=49.95 decpoint=41.51 roll=0.00 exposure=200000. insrcdeffile=perseus_betaicm_brptsrc.dat outfile=perseus_betaicm_brptsrc.fits psffile=$HEASIM_SUPPORT/**astro-h**/sxs/psf/eef_from_sxs_psfimage_20140618.fits vigfile=$HEASIM_SUPPORT/**astro-h**/sxs/vignette/SXT_VIG_140618.txt rmffile=$HEASIM_SUPPORT/**astro-h**/sxs/response/**ah_sxs_5ev_20130806.rmf** arffile=$HEASIM_SUPPORT/**astro-h**/sxs/response/**sxt s_140505_ts02um_CBF_intall_140618psf.arf** intbackfile=none flagsubex=no seed=1234567890 clobber=yes

In Xspec, use **ah_sxs_5ev_20130806.rmf**, **sxt-s_140505_ts02um_CBF_intallpxl.arf**

You may wish to... Filter events

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- **Use HP and MP for hi-rez spectroscopy.**
- **Rule of thumb: check branching if >1 ct/sec/pixel.**

sxsbranch

- computes branching ratios for each event resolution grade -- for each pixel, and over the entire array
- statistically estimates these quantities using Poisson statistics, based on some count distribution in pixels
- **produces a more realistic version of the event file by populating the PIXEL, and ITYPE columns with the grade (ITYPE = 0:HP, 1:MP, 2:MS, 3:LP, 4:LS)**

```
sxsbranch infile=perseus_betaicm_brptsrc.fits filetype=sim
outfile=perseus_betaicm_brptsrc_branch.out pixfrac=$HEASIM_SUPPORT/astro-h/sxsbranch/
pixfrac.txt  pixmask=none
```

For example, in Xselect...

- xsel:HITOMI-SXS-PX_NORMAL > read events **perseus_betaicm_brptsrc.fits.out**
- xsel:HITOMI-SXS-PX_NORMAL > filter column "PIXEL=27:35" *corner of the array*
- xsel:HITOMI-SXS-PX_NORMAL > filter GRADE "0:1" HP only (1:MP, 2:MS, 3:LP, 4:LS)

DOs, DON'Ts and Takeaways

XRISM X-Ray Imaging and Spectroscopy Mission

- DO install XRISM build 1 and the simulation support files.
- For isolated point sources, Xspec sim is sufficient – but DO run *sxsbranch* if the source is bright.
- DO use Xspec to create input spectra for your simulation.
- DO take advantage of the multi-component source capabilities of heasim and Xspec.
- For Resolve, one DOES NOT need the source to extend beyond ~6 arcmin.
- DO use the point source ARF with vignetting for extended sources to get the most accurate count rate. But...
- DO be mindful of norms for extended sources (use the correct ARF in Xspec to get the right flux).
- For Resolve, the NXB is negligible for most cases
- Please DO direct all questions, concerns, requests to...

XRISM-SDC-help@lists.nasa.gov (there's a form!).